National Aeronautics and
Space Administration

Educational Program	
Educators & Students	Grades 5–12

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NASA
Student Involvement Program
Watching Earth Change

Educator's Resource Guide

2000–2001
National Competitions

NSIP

Watching Earth Change

This Educator's Resource Guide is designed to help you explore how watching the Earth from space can be an exciting part of your science courses. This newly revised Guide includes new sections, including guidelines for student research, an introduction to satellite observations of the Earth, and many new references to related learning activities and NASA education resources. In addition, a section containing rubrics has been added to provide a clear idea of how your students' entries will be judged. You may wish to use these rubrics as an assessment tool if you use the **Watching Earth Change** competition as a class assignment.

The Guide is designed for teachers of grades 5–12. This is a wide age range, so feel free to adapt the materials and activities to make them easier or more challenging. Use this Teacher's Guide as a supplement to the current NSIP Program Announcement brochure which provides full details on the NSIP Program and entry forms to submit your students' entries.

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Competition Categories

Grades 5–8	Teams of 2–4 Students
Grades 9–12	Individual Students

Watching The Earth

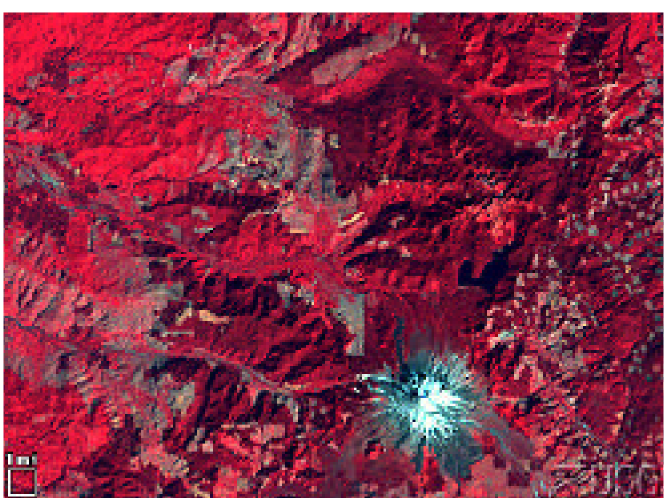
Look closely at these satellite images below, taken of Mount St. Helens in the years before and after its dramatic 1980 eruption. The red coloring represents vegetation; white represents the absence of vegetation. What changes do you see?

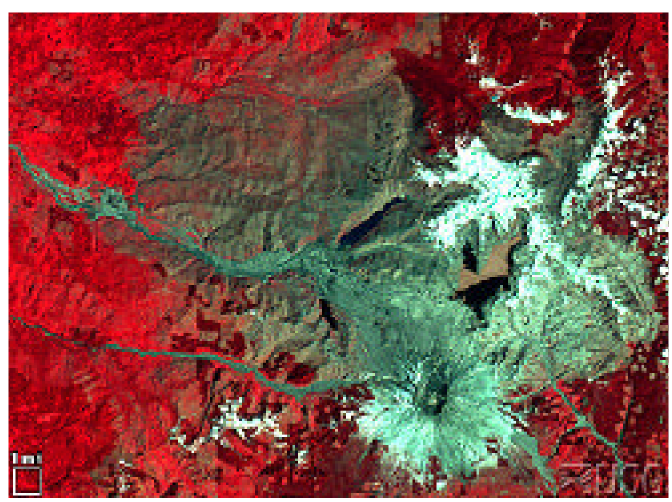
By comparing these images, you can observe the extreme effects of this volcanic eruption and the gradual reshaping of the area in its aftermath. You may also see the crater, the ash distribution, the mudslides, the re-growth of vegetation, and more.

These images were taken by sensors aboard Landsat, one of the many satellites in orbit around the Earth. Sensors on other satellites are detecting changes in the temperatures of our oceans and our atmosphere;some monitor the ever-changing cloud patterns. Some are measuring the extent of different particles and gases that pollute our skies. One well-known example of this is the case of ozone. Depletion of the ozone layer has been closely monitored from space since 1978. These data, together with measurements of ozone taken from the ground, have enabled us to understand and take decisive international action against the degradation of the Earth's atmosphere.

Satellite-borne sensors are tuned to receive and record the different kinds of radiation that emanate from various features of the Earth. How does this work? The process is simply an extension of how we see: Every object has colors that we can see when light reflects off the surface of the object and enters our eyes. Visible light is just one kind of radiation coming from the object:it is the kind to which our eyes are attuned. But there are other kinds of radiation that our eyes cannot register, and which are invisible to us. Scientists have developed many instruments to detect "invisible" kinds of radiation.A familiar example of such instruments is night-vision goggles—in the absence of reflected light, these goggles sense the heat radiating from objects. Instruments that can detect radiation of various kinds are called *remote sensing* instruments—and "remote" in this context means "without touching". So you see, our eyes are remote sensors too!

Now imagine a whole fleet of remote sensing satellites collecting data about the Earth continuously: this is the centerpiece of NASA's Earth Observing System. Other parts of the system involve the storage, display, and interpretation of all the data collected by instruments in orbit, on balloons, in aircraft, on ships, and from the ground. These resources have dramatically transformed how scientists conduct Earth science research. Check the "Resources" section of this Guide (pg. 16) to learn more about NASA's Earth Observing System.





What Your Students Will Learn

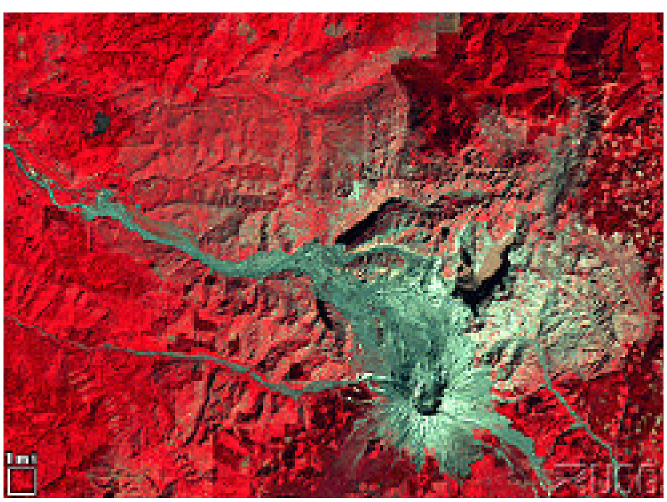
Through this NSIP competition, your students experience some of the same challenges as NASA's Earth scientists and satellite engineers. Your students use real images and other data about Earth, search for evidence of Earth changes, and prepare a research report to share their findings. Whether or not your students win the competition, these activities will stimulate meaningful research, enhance science knowledge, and develop higher level thinking skills.

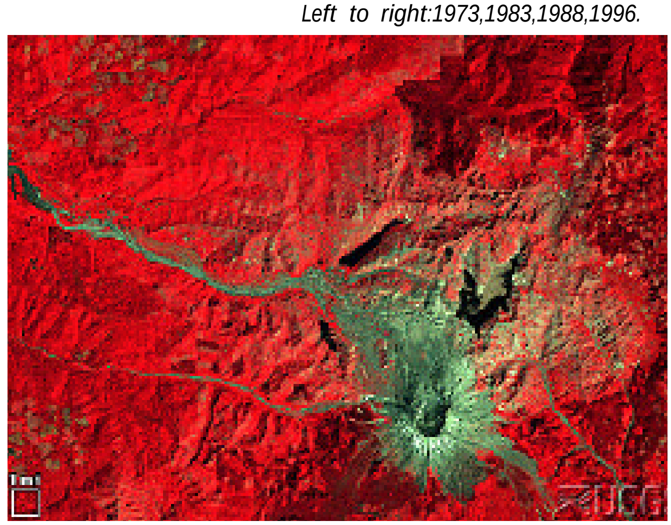
The learning goals of NSIP are in accord with national standards for science education. Your students will:

- Learn core concepts in Earth science.
- Develop skills of scientific inquiry.
- Think like a geographer, exploring issues of where and why.
- Experience the unifying concepts and processes of science.
- Gain new skills with technology (computers, Internet, image and data analysis).
- Appreciate the multi-faceted roles of science in our society.
- Develop visual thinking and problem-solving skills.
- Work collaboratively as team members.
- Communicate more clearly and effectively.

Mt. Pinatubo in the Philippines, as viewed from the ground, 1991.

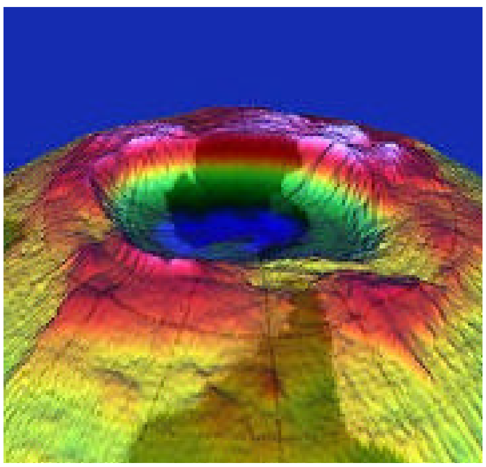
Landsat images of Mt. St. Helens Left to right: 1973, 1983, 1988, 1996.





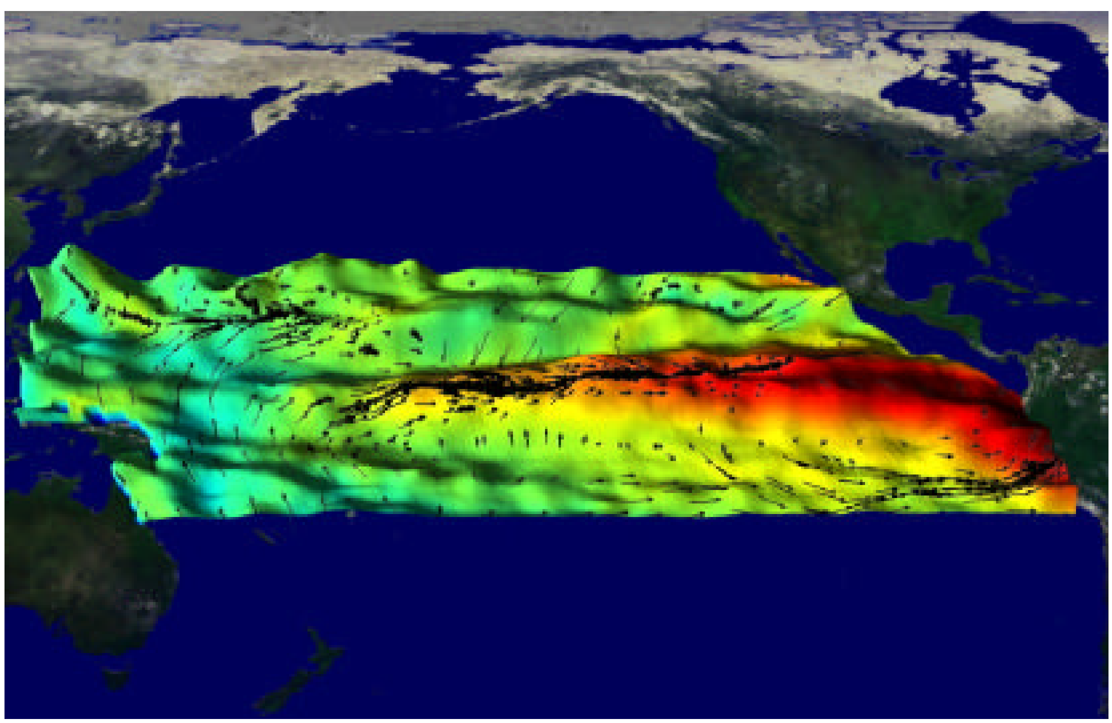
A Dynamic Planet

Ozone hole over Antarctica: Shaded areas represent Antarctica (towards the top) and South America (at the bottom). This image is a 3-D rendering of ozone data from the TOMS instrument.



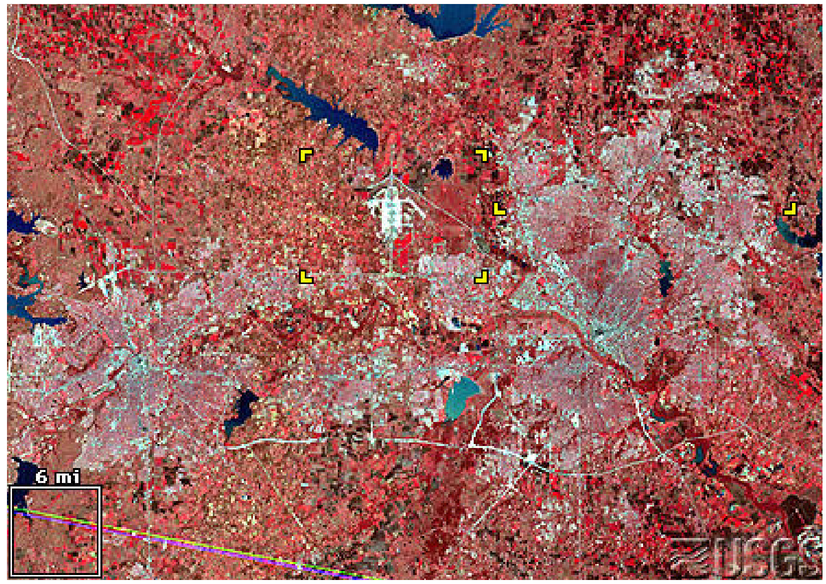
Earth changes take place over many scales of time and space. What you see depends on a number of factors, including the instruments you use, what features you focus on, and how often you check. Your students' research project may focus on any type of change within the Earth system, whether natural (e.g.,monsoon, deforestation, sea ice melting, ozone depletion) or human-induced (e.g., urban growth,habitat loss, air pollution, water management). The Earth's systems interact perpetually in an interesting and intricate dance. For most of us, the cycle of the seasons is the most obvious one, and so provides a great entry point for thinking about the Earth. As summer gives way to winter, so too are other cycles constantly in motion: atmosphere and ocean circulate continuously, but, as we have recently learned, not independently. The severity of recent El Niño events has brought an awareness of this minuet between air and ocean into clear focus. El Niño is but one of many phenomena that show how different parts of the Earth system not only interact but are intimately coupled: cycles within cycles. Only in the past few years, with the benefit of extensive satellite observations of the oceans, have scientists learned how to predict El Niño. There is still much to discover about the Earth's dynamic cycles. Get to know this complex and beautiful planet. NASA's archive of data and images of the Earth's various faces is available over the Internet to all researchers, including you and your students (see "Resources" on pg. 16.) Earth is a dynamic planet and it is important for students to observe, analyze, and understand how it changes over short and long periods of time. Here is an opportunity to do some exploration!

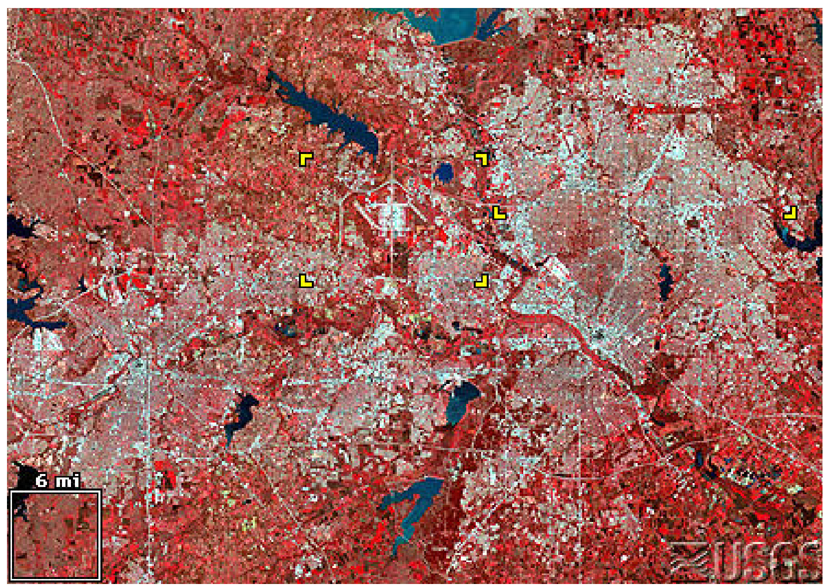
El Niño of 1997–1998. Sea surface temperature anomaly is represented by color (red is hotter, blue is colder). Sea surface winds anomaly is represented by black arrows, showing direction and magnitude. Sea surface height anomaly is represented by the ripples;note the peaks and valleys. Data was collected by instruments on the TOPEX/ Poseidon satellite during July 1997.



Environmental Changes as Viewed from Space

Visit the U.S. Geological Survey's Earthshots ***(http://edcwww.cr.usgs.gov/earthshots/slow/tableofcontents)*** to find over twenty different locations which dramatically illustrate environmental change. Compare the two to five images of each location that were taken over the last three decades. The images, along with articles and references, are grouped thematically: agriculture, city, desert, disaster, forest, geology, water, wildlife. Here is a sample of investigations you might consider.

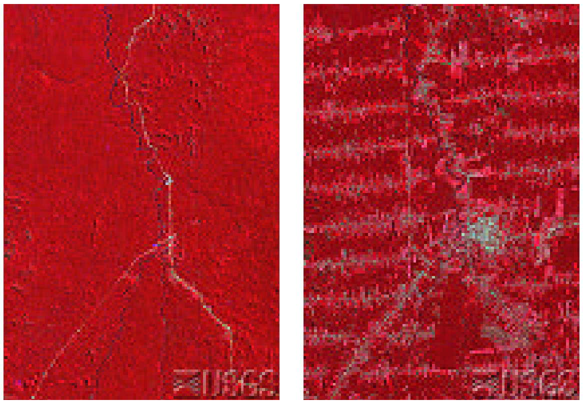




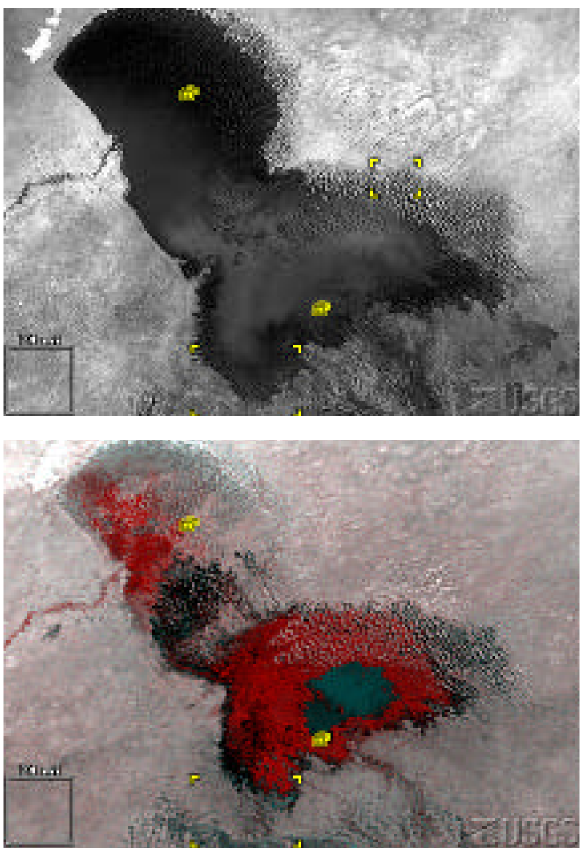
I. Growth of a City

The map on the top shows Dallas, TX in 1974. The Landsat below that shows the same area in 1989. You can see the growth of roads and human settlement from the central urban areas into the surrounding rural areas in just 12 years.

Exploration Example: Check the Earthshots web site for images of cities around the world. Your students can investigate human settlement patterns in a single city or compare several cities around the world. Students can explore questions such as: Why has it grown more in some directions than in others? What new transportation patterns (such as highways or airports) have emerged and how have they affected the city?



Landsat images of the Rondonia region of Brazil.
Left image: June 1975; right image: June 1992.



Satellite images of the Lake Chad area of Africa.
Top: Argon image, October 1963;
Bottom:NOAA 14 AVHRR image, July 1997.

II. Deforestation

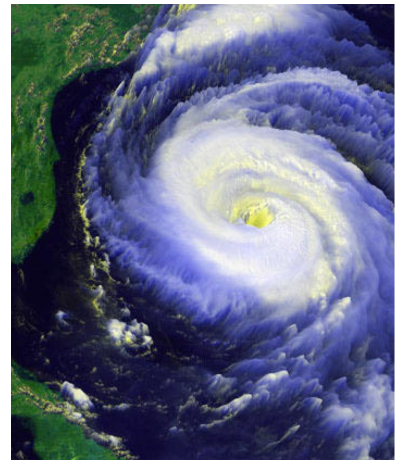
In the Rondonia region of Brazil (left images),deforestation burning is often done in a well defined, grid-like network,making way for the new roads, settlements, and farming areas being established in these areas. The expansion of such deforested areas can be measured by comparing images of the same region over a period of several years, as in these two images.

Exploration Example: These, and other forest images, can be found on the Earthshots web site. Students might measure the areas affected by deforestation, such as shown in the Rondonia images.

III. Lakes and Rivers, and Ice Shelves.

Water is the a great agent of change in our Earth system. But it also suffers dramatic changes in relatively short periods of time. Lake Aral, Lake Chad, and the Great Salt Lake are dramatic examples of such changes. A look at the polar regions will reveal changes in the shape and quantity of sea ice and ice shelves.

Exploration Example: The Earthshots web site has many images of lakes to choose from. Your students might compare the conditions under which these enormous bodies of water underwent radical change. An article about Antarctica's Filchner Ice Shelf may be a good starting point for thinking about the effects of climate change. Check the Resources section of the NSIP web site for more data and resources on sea ice.



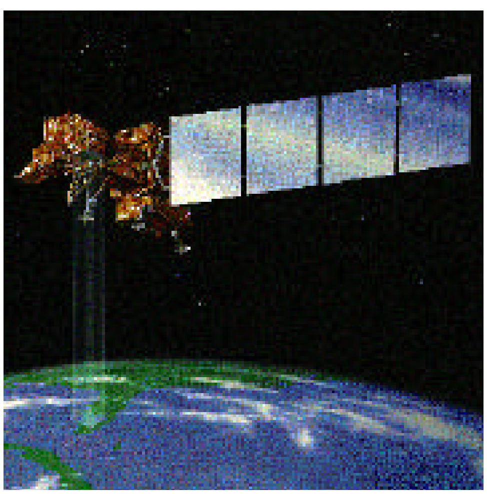
IV. Tracking a Hurricane

Hurricane Fran approached the Florida peninsula in early September 1996.Like many hurricanes, Fran changed course and headed north along the Eastern Seaboard. It devastated the Carolinas with 115-mile-an-hour winds. The GOES-8 satellite watched Fran's ominous image continuously, giving meteorologists at the National Hurricane Center in Florida a clear view of the approaching storm. Using the satellite as their eye in the sky, they issued timely warnings to people living in her path.

Student Investigation: During hurricane season, your students can monitor a hurricane's changing size, shape, and track by downloading a new weather satellite image every few hours as the storm progresses. For a research project on this topic, visit NASA Goddard Space Flight Center's Earth and Space Sciences Education Project, select "Investigation Titles" and look for "The Hurricane Predictors." The project provides useful data sources within the standards-based educational framework of a student investigation. Go to: ***http://edmall.gsfc.nasa.gov/inv99 Project.Site/invhome.html***

Sources Of Data

Many satellites orbit the Earth, collecting a broad array of data for use by scientists and the general public. One excellent guide to the constellation of satellites is the *NASA's Remote Sensing Tutorial* ***(http://rst.gsfc.nasa.gov).*** This comprehensive work not only discusses the satellites but also the object of their continuous attention: the Earth system. You may want to see the Resources section for a more technical version of this work *(Geomorphology from Space),* also available online. A brief introduction to some of the satellites appears on this page.



Artist's rendering of the Landsat 7 gathering data.

Landsat Satellites

Landsat is an especially valuable remote-sensing resource for probing earth's surface, and especially features and changes on land. Since 1972, Landsat satellites have collected detailed data about Earth. Its sensors collect data on vegetation,mineral composition, and soil moisture, among other features of the Earth's surface. You have seen many such images in this Guide. A formal tutorial about Landsat can be found on NASA's Landsat website Education page, and the USGS Earthshots site.

NASA:
http://landsat.gsfc.nasa.gov/main/education.html

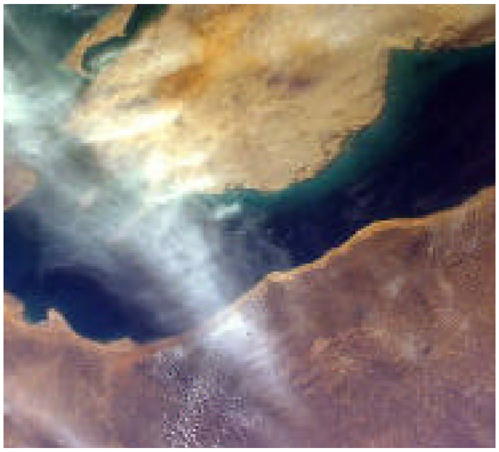
USGS:
http://edcwww.cr.usgs.gov/earthshots/slow/Help-GardenCity/Help-GardenCity

Weather Satellites

Probably the most familiar remote sensing images, which millions of people now simply expect to see every day, are images from weather satellites. The images that we see on television are usually from satellites which view the same hemisphere at all times. They do this by keeping up with the Earth as it spins on its own axis. Since its motion is synchronized with the Earth's rotational motion,such a satellite is called "geosynchronous," or "geostationary". The GOES 8, Geostationary Operational Environmental Satellite, for example, is located over the equatorial Atlantic Ocean and provides weather images for the continental US and Atlantic Ocean. These images are especially valuable for exploring hourly changes in storm systems and cloud patterns. But GOES' view of the Earth is restricted to only the mid-latitudes of only the western hemisphere, so Europe, Africa, Asia,and the poles are hidden from its view. Other satellites (such as Meteosat) provide weather data for the eastern hemisphere. See the "Resources" section (pg. 16) for web sites that have real-time GOES images and image archives of historic hurricanes ***(http://rsd.gsfc.nasa.gov/goes).***

Other Earth-Observing Satellites

The importance of having a complete and continuous record of the Earth cannot be underestimated. Other research satellites circles the globe almost directly over the North and South Poles. These polar-orbiting satellites, such as the NOAA-POES,provide more coverage of the Earth's surface, but repeat this coverage only once every 12 hours. One example is a polar orbiting environmental satellite that houses the Total Ozone Mapping Spectrometer (TOMS) to monitor atmospheric ozone. TOMS is an important source of data needed to monitor polar ozone holes. The most recent Earth observing satellite launched to date is also one of the most exciting. **Terra** (formerly EOS-AM-1) was successfully launched on December 18, 1999. According to *NASA's Remote Sensing Tutorial,* this event "…commences one of the most ambitious and important programs of the space era,in view of its goal to obtain a variety of data sets simultaneously as a means of conducting integrated environmental studies on a near-global scale." The Tutorial goes on to present Terra's view of the Earth in an impressive array of sample images from each of the five sensors aboard this amazing satellite. See this section of the Tutorial ***(http://rst.gsfc.nasa.gov/Sect16/Sect16_9.html)*** for more.



Astronaut Photos and the EarthKAM Program

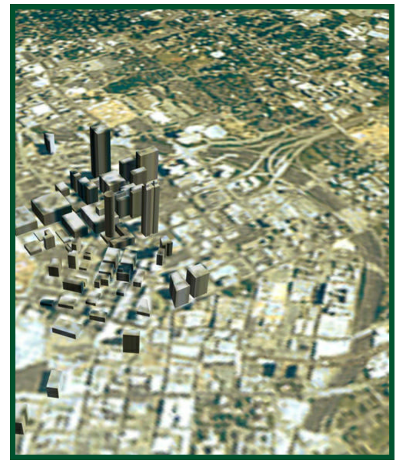
Since the early days of human space flight, astronauts have taken hundreds of thousands of pictures of Earth from space. Astronauts take pictures of Earth in what is now a well-coordinated program of pre-planned and spur-of-the-moment pictures. Astronauts bring a unique human perspective to Earth observation, scanning the area under the Space Shuttle for interesting features or processes. The Johnson Space Center maintains the astronaut image archive and has a web site with some of the best images ***(http://www.earth.jsc.nasa.gov).*** To date, astronauts have taken over 300,000 photos of Earth.

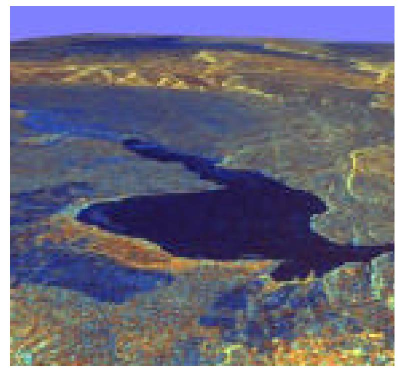
NASA's EarthKAM project provides a new resource of images. Middle school students in a select group of schools used a digital camera flown on the Space Shuttle to take approximately 2,000 images of Earth, all of which are now available on the Web ***(http://earthkam.ucsd.edu).*** See "Resources" (pg.16) for web sites, books, and posters with astronaut's photos and images from the EarthKAM project.

The GLOBE Program and Ground-Truthing

Satellite images and other data are critical to our studies of Earth. However, they are only part of the puzzle. Observations from the surface of Earth provide additional supportive data. Such surface observations serve as "ground-truth" data to help calibrate and validate remote-sensed observations. In the NSIP competition, your students can use ground-truth data (which could even come from a field trip by your class) to supplement and support the remote-sensed images. The best source of ground-truth data gathered by students from around the world is the GLOBE Program. Global Learning and Observations to Benefit the Environment (GLOBE*) is a hands-on international environmental science and education program. GLOBE links students, teachers, and the scientific research community in an effort to learn more about our environment through student data collection and observation. The GLOBE web site offers access to all GLOBE data and will plot the data as a graph or let you download the data for analysis. Go to ***http://viz.globe.gov*** to learn more.

You may want to examine the GLOBE Teacher's Guide at ***http://www.globe.gov*** for ideas and activities. If you are already a GLOBE teacher, the NSIP competitions provide a forum for your students to gain broader recognition for their research. Enter the results of your research!



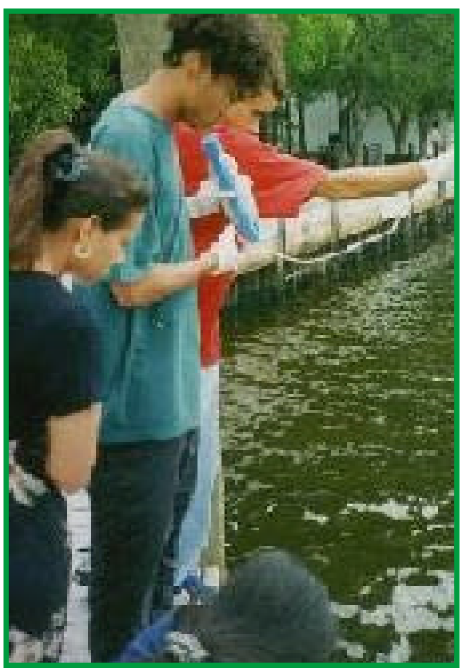


The goals of GLOBE are:

- *To enhance the environmental awareness of individuals throughout the world;*
- *To contribute to scientific understanding of the Earth; and*
- *To help all students reach higher levels of achievement in science and mathematics.*

—GLOBE Teacher's Guide, p.6

Sample Learning Activities

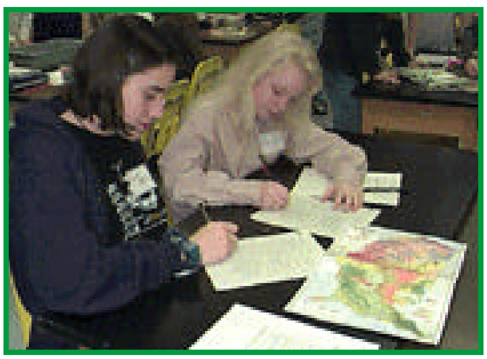


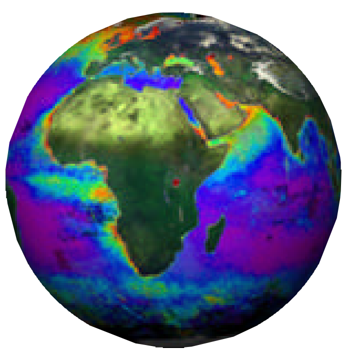
There are many learning activities that could be used as starting points for your **Watching Earth Change** project. The "Resources" page of this guide contains a section, *Student Investigation Modules,* which contains nearly one hundred of them (pg. 16). They have been created over the last 4 to 5 years for various grade levels, and for different levels of experience, both with the subject matter and with the technology needed to delve into it. Regardless of the actual topic and grade level,what they have in common is an approach which begins with guided inquiry and eventually leads to open-ended problem-based learning, thus giving students the opportunity to engage in the process, define their own questions, do some exploring and produce their own answers. This is the heart of national science education standards:authentic experiences in science.

Another thing that these activities have in common is they are wonderful collections of data and information resources that they have assembled under a given topic. The depth and usefulness of these resources vary, as do the educational level and value of each of the modules. Nevertheless they provide you and your students with a breadth of starting points for original activities.

What follows is a brief discussion of the research process. It is hoped that the process described here, or something much like it, will result in a fruitful research experience, and a winning project report. The steps outlined are related to the project report components and the judging rubrics that will be used to judge all **Watching Earth Change** entries.

Prepare Your Entry





The Research Process

The process described here is intended for use with all age groups. Two important points must be kept in mind. *First,* the process of research is not a simple sequence of steps, like recipe or a lab report. It is really about deepening the original question, so the process involves a lot of going back to re-examine earlier assumptions. *Second,* since your students are of different ages and ability levels the process that appears here is intended to be adaptable. The main point of research is to find an interesting question, to pursue it, to deepen one's understanding of it, and to find answers along the way. In this pursuit, older and more advanced children are expected to use more of the language and tools of science than their younger counterparts will. We have tried to reflect this understanding in the judging rubrics as well.

I. Selecting a Topic of Interest

Scientific inquiry can originate from any number of topics. The switch from an interesting topic to a scientific investigation happens when the words "I wonder…" cross the mind: A research question is born.

II. Background Research

What is known about your topic? Discuss, read, browse web sites listed in this Guide, look at images, and discuss your ideas. This is a recurring part of all research which can help students focus the hypothesis. It will shorten the search for suitable data, images, maps, etc.

III. Turning the Question into a Hypothesis

How does a question that begins with "I wonder…" become a full-fledged research question? First, does the question even admit of an answer, and if so, can the question be answered by your students within the limits of their resources (e.g., literature at the right reading and conceptual level, equipment, access to information, etc.)? Second, if at least part of the question is *testable,* then it is on its way: such questions could be answered with the right data, information, images, maps. A hypothesis is a *testable* statement about the research question. Because test results will either support or falsify it, a good hypothesis can guide research toward answers. A researcher makes a question testable by identifying variables and proposing a relationship among them. For younger students, the process of isolating variables and using controls can be expressed in terms of "doing a fair test."

IV. Planning

Once the question is focused, and testable parts are identified, there needs to be a plan of action: what is going to count as evidence that would support or refute the hypothesis? What information is needed to do so? What data are suitable and ready for use within a reasonable amount of time and effort—time-limitation is an important factor to consider in shaping any research project.

V. Analysis

How will students analyze the data, images, maps, etc. that they've collected in order to make the case for or against the hypothesis? What sorts of relationships will students look for? What sorts of diagrams and graphs will display and demonstrate these relationships clearly and convincingly?

V. Communicating the Findings.
When the research is done and the dust has settled there is one last and crucial challenge: to present the investigation in an engaging way that informs, educates, and convinces.

Research Project Components

(The following description of research project components was taken from the NSIP 2000–2001 Program Announcement.)

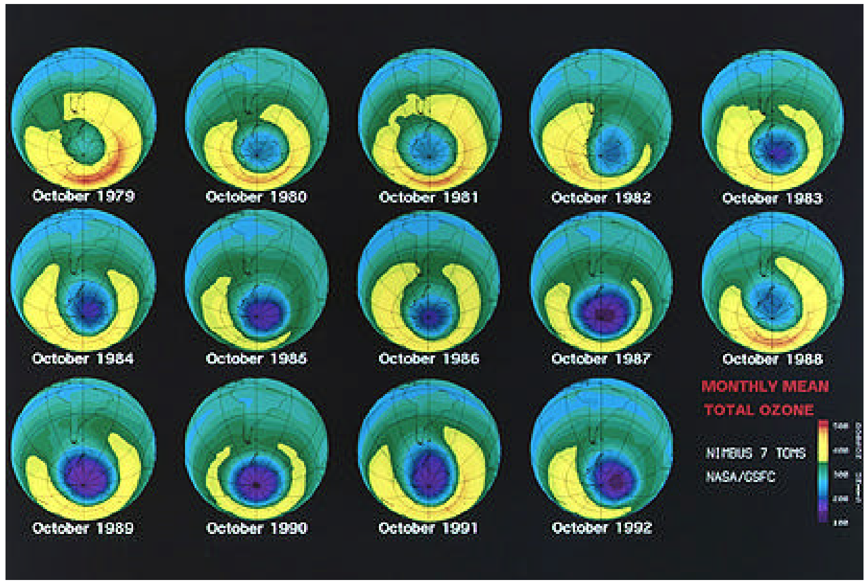
I. Focus of Investigation
Select one type of natural or human-induced change for your project. Briefly describe the general nature, causes, and impact of this type of change. Then define your research question, explain why you are interested, and how satellite images and data will help you answer your question.

II. Documentation of Images, Data, Maps, and Graphs
Provide a print of the images, data,maps, and graphs used in your investigation,with key features labeled. State the type of instrument or sensor used (e.g., Landsat, SeaWiFS),and the kind of data it collected. Identify the location (latitude and longitude) and the dates and times (if appropriate). When using images, provide a labeled map and a brief description of the region around the images.

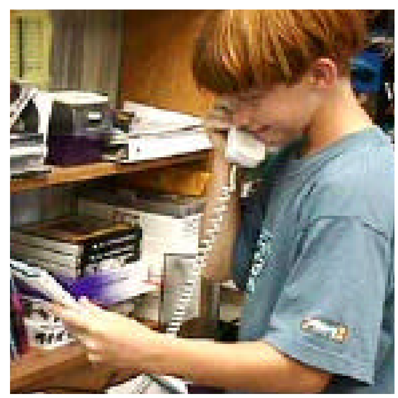
III. Analysis and Discussion
Discuss how the region has changed over time and how it might change in the future, specifying the evidence found in the images and other data. This is to be your own interpretation of the data. Consider the following approaches:a) compare data or images of a given region that were obtained at different times (decades, years, hours, or minutes apart);b) compare data or images obtained at the same time but at different locations;c) compare data or images of a given region obtained at the same time, but by different instruments. Specify which approach (or combination of approaches) you used and how this helps answer your specific research question.

IV. Resource Credits
List all reference books, periodicals, web sites, and people (including names, work titles, and type of help provided) that contributed to your research.

To get a detailed description of how these components will be evaluated, examine the Judging Rubrics on the following pages.



14 Octobers.
A comparison of Antarctic ozone between 1978 and 1992. Notice the steady depletion of ozone over the South Pole.



Watching Earth Change
JUDGING RUBRICS

100 Points Total

NOTE: The following Judging Rubrics supersede the abbreviated "Judging Criteria" that appear in the NSIP 2000–2001 Program Announcement brochure.

The rubrics are designed for all grade levels. Our operating assumption is that teachers will adapt these rubrics as appropriate to match requirements of their students. Middle and high school rubrics may differ only with respect to research question vs. hypothesis:emphasizing the process of identifying a testable hypothesis and designating variables may be more appropriate to high school entries than to middle school entries.

RESEARCH & ANALYSIS

70 Points Total (*For breakdown,see Rubric Table on pg. 14*)

1. Research Question and Hypothesis: *What is the research question? Does the hypothesis focus the investigation of that question? What variables were selected for study?*

0 No research question and/or hypothesis is stated.
1 A research question and/or hypothesis is/are present but poorly stated, and may contain inaccuracies.
2 A clear research question and/or hypothesis is/are stated is not testable, or variables not identified.
3 The research question is clear, and/or the hypothesis is testable, and variables are identified.
4 The research question is clear, and/or the hypothesis is focused and compelling, variables are identified as dependent, independent, and control (if appropriate).

2. Background Research: *Does the report demonstrate a clear understanding of relevant facts and theories?*

0 Understanding is confused;most statements about basic facts and theories are missing or incorrect.
1 Understanding is somewhat clear; some statements about basic facts and theories are incorrect or missing.
2 Understanding is mostly clear; most statements about basic facts and theories are relevant and correct; relevant resources are cited.
3 Confident understanding of relevant facts and theories; relevant resources are cited from multiple sources(i.e.,not exclusively Internet).
4 Demonstrates mastery over relevant field of facts and theories, relevant resources are cited from multiple sources (i.e.,not exclusively Internet).

3. Research Plan: *Is there a clear research plan and does it address the research question and hypothesis?*

0 No clear plan is apparent.
1 Plan is unclear, most steps are missing or confused;it relates poorly to the research question.
2 Plan is somewhat clear, main steps are present, and somewhat relevant to the research question and hypothesis.
3 Plan is clearly stated, most steps are present, and will yield answers relevant to the research question and hypothesis.
4 Plan will clearly yield answers that address the research question and hypothesis in a compelling way.

4. Data and Graphics: *Does the report utilize relevant data,images, maps, and graphs to support the research question and hypothesis?*

0 Data or graphs are present but have little relevance to the research question, hypothesis, or analysis.
1 Data and graphs are present and have some relevance to the research question and may serve as the basis for analysis.
2 Data and graphs strongly address the research question and serve to justify the analysis;presentation lacks labels, legends, or captions.
3 Data and graphs strongly address the research question and justify the analysis;presentation of data lacks little or nothing.
4 Data and graphs make a compelling case about the research question and hypothesis;data are presented clearly and informatively.

5. Analysis and Conclusions

0 Background research ,data,images are poorly utilized, and not relevant to the research question and the hypothesis.
1 Background research ,data,images are utilized to make a weak case about the research question and the hypothesis.
2 Background research ,data,images are utilized to make a fair case about the research question and the hypothesis.
3 The analysis shows creativity, makes a good case to confirm or refute the hypothesis;deep understanding of research question.
4 The analysis shows originality and creativity, draws compelling conclusions about the research question and hypothesis; discusses sources of error.

COMMUNICATION

30 Points Total *(For breakdown,see Rubric Table on pg. 15)*

1. Presentation of Research and Conclusions

0 Poor presentation, evidence of last minute efforts, no clear organization,significant components are missing.
1 Presentation is plain,but lacks clear organization,not engaging; poor presentation of data and graphs.
2 Presentation is plain,somewhat clearly organized, somewhat engaging;data and graphs are presented adequately.
3 Presentation is creative, clearly organized, and engaging;data and graphics are informative.
4 Presentation is creative and original,clearly organized;engaging and persuasive;data and graphics are informative.

2. Resource Credits

0 Resources are not present.
1 Minimal resources are cited.
2 Contains citations from few sources;citations are indirectly related to the report.
3 Contains some relevant citations from multiple sources (i.e.,not exclusively Internet);citations are directly related to the report.
4 Contains many relevant citations from multiple sources (i.e.,not exclusively Internet);citations are directly related to the report.

RESEARCH & ANALYSIS 70 Pts. Total

POINTS	1. RESEARCH QUESTION AND HYPOTHESIS *What is the research question? Does the hypothesis focus the investigation of that question? What variables were selected for study?*	2. BACKGROUND RESEARCH *Does the report demonstrate a clear understanding of relevant facts and theories?*	3. RESEARCH PLAN *Is there a clear research plan and does it address the research question and hypothesis?*	4. DATA AND GRAPHICS *Does the report utilize relevant data, images, maps, and graphs to support the research question and hypothesis?*	5. ANALYSIS AND CONCLUSIONS
0	No research question and/or hypothesis is stated.	Understanding is confused;most statements about basic facts and theories are missing or incorrect.	No clear plan is apparent.	Data or graphs are present but have little relevance to the research question, hypothesis, or analysis.	Background research, data,images are poorly utilized, and not relevant to the research question and the hypothesis.
1	A research question and/or hypothesis is/are present, but poorly stated and may contain inaccuracies.	Understanding is somewhat clear; some statements about basic facts and theories are incorrect or missing.	Plan is unclear, most steps are missing or confused;it relates poorly to the research question.	Data and graphs are present and have some relevance to the research question and may serve as the basis for analysis.	Background research , data,images are utilized to make a weak case about the research question and the hypothesis.
2	A clear research question and/or hypothesis is/are stated but not testable, or variables not identified.	Understanding is mostly clear; most statements about basic facts and theories are relevant and correct; relevant resources are cited.	Plan is somewhat clear, main steps are present, and is somewhat relevant to the research question and hypothesis.	Data and graphs strongly address the research question and serve to justify the analysis;presentation lacks labels, legends, or captions.	Background research, data,images are utilized to make a fair case about the research question and the hypothesis.
3	The research question is clear, and/or the hypothesis is testable, and variables are identified.	Confident understanding of relevant facts and theories; relevant resources are cited from multiple sources (i.e.,not exclusively Internet).	Plan is clearly stated, most steps are present, and will yield answers relevant to the research question and hypothesis.	Data and graphs strongly address the research question and justify the analysis; presentation of data lacks little or nothing.	The analysis shows creativity, makes a good case to confirm or refute the hypothesis; deep understanding of research question.
4	The research question is clear, and/or the hypothesis is focused and compelling; variables are identified as dependent, independent, and control (if appropriate).	Demonstrates mastery over relevant field of facts and theories; relevant resources are cited from multiple sources (i.e.,not exclusively Internet).	Plan will clearly yield answers that address the research question and hypothesis in a compelling way.	Data and graphs make a compelling case about the research question and hypothesis;data are presented clearly and informatively.	The analysis shows originality and creativity, draws compelling conclusions about the research question and hypothesis;discusses sources of error.
	Points_____ x 15 = Subtotal_______ +	Points_____ x 10= Subtotal_______ +	Points_____ x 15 = Subtotal_______ +	Points_____ x 15 = Subtotal_______ +	Points_____ x 15 = Subtotal_______ =

Total of Above Subtotals __________ ÷ **4** = ___________
TOTAL POINTS

COMMUNICATION 30 Pts. Total

POINTS	1. PRESENTATION OF RESEARCH AND CONCLUSIONS	2. RESOURCE CREDITS
0	Poor presentation, evidence of last minute efforts, no clear organization,significant components are missing.	Resources are not present.
1	Presentation is plain,but lacks clear organization,not engaging; poor presentation of data and graphs.	Minimal resources are cited.
2	Presentation is plain,somewhat clearly organized, somewhat engaging;data and graphs are presented adequately.	Contains citations from few sources;citations are indirectly related to the report.
3	Presentation is creative, clearly organized, and engaging;data and graphics are informative.	Contains some relevant citations from multiple sources (i.e.,not exclusively Internet);citations are directly related to the report.
4	Presentation is creative and original,clearly organized;engaging and persuasive;data and graphics are informative.	Contains many relevant citations from multiple sources (i.e.,not exclusively Internet);citations are directly related to the report.
	Points________ x 6 = Subtotal______________ +	Points________ x 1.5 = Subtotal______________ =

TOTAL POINTS ____________

Resources

These resourcers are updated periodically. Check the Watching Earth Change web site at ***http://www.nsip.net/c_toc.html*** for the best and most up-to-date version.

NSIP Competition Announcement

Full details for the NSIP competition are presented in the official NSIP Competition Announcement (EP-1998-10-367-HQ). To get a copy:

- download from the NSIP web site—***http://www.nsip.net***—or
- call to request a printed copy at 1-800-848-8429, toll free.

NSIP Web Site

Check the web site frequently for updates.

http://www.nsip.net

Student Investigation Modules

The following curriculum modules and activities bring the world of online Earth science data into your classroom, in a thoughtful and teacher-friendly form.

GESSEP: The Goddard Earth and Space Science Investigations

http://edmall.gsfc.nasa.gov/inv99 Project.Site/invhome.html

Over 70 student investigations were developed by teachers with expertise in the use of technology to access real time and/or current data for use in meeting education standards in science, mathematics, technology, and geography. Written for teachers by teachers, these modules were developed over a period of four summers with the support and collaboration of NASA Goddard Space Flight Center scientists and education specialist.

NASA Classroom of the Future: Exploring the Environment

http://www.cotf.edu/ete/

The ETE online series emphasizes problem-based learning (PBL) and collaborative learning groups for student-directed inquiry into Earth systems education. The modules encourage students to think, to solve problems, and to write and speak clearly. ETE modules incorporate the use of remotely-sensed satellite images of the earth taken from NASA satellites or aircraft. There are many useful tips in the ETE Teacher Pages.

SEGway's Sun-Earth Investigations

http://cse.ssl.berkeley.edu/segway/ sun_ear_list.html

The Science Education Gateway (formerly SII) is a collaborative NASA project which brings together the expertise of NASA scientists, science museums, and K–12 educators to produce NASA science-based Earth and space science curricula for classroom and public use. The SEGway Web site is designed to help teachers locate and identify the resources they can use best and that fit their local curriculum and National Science Education Standards.

Great Earth Web Sites

"Billions and billions" is good for stars but not for web sites. These few are among the very best. They also include their own list of favorites.

Earthshots: Satellite Images of Environmental Change

http://edcwww.cr.usgs.gov/ earthshots/slow/tableofcontents

Earthshots is an e-book of before-and-after Landsat images (1972–present), showing recent environmental events and introducing remote sensing. Earthshots comes from the U.S. Geological Survey's EROS Data Center, Sioux Falls S.D., the world's largest archive of earth science data and the official National Satellite Land Remote Sensing Data Archive.

Landsat in the Classroom

http://landsat.gsfc.nasa.gov/main/ education.html

Landsat 7 is a U.S. satellite used to acquire remotely sensed images of the Earth's land surface and surrounding coastal regions. This site features Landsat 7 education applications. It is maintained by the Landsat 7 Project Science Office at the NASA Goddard Space Flight Center in Greenbelt, MD.

NASA's Earth Observing System

http://eospso.gsfc.nasa.gov/eos_ homepage/images.html

Many great remote sensing resources are organized into three levels: 1) Beginners—web sites that provide an overview with a broad sampling of images from various NASA programs; 2) Intermediate—NASA program specific pages which contain images/video on a specific research topic; and 3) Advanced-detailed pages on specific data sets, intended for the research community and advanced user.

The EROS Data Center Selected Image Gallery

http://edc.usgs.gov/bin/html_web_ store.cgi

The EROS Data Center houses millions of images—aerial photographs, mainly for mapping, and various kinds of satellite images for scientific study. Among all these pictures, naturally, are some that are beautiful, some that record events of historic significance, and some that stir the imagination for other reasons. This page contains a selection of such images, available from EROS Customer Services as photographic products in sizes up to 40 inches square. Next to each image is the size of the graphic file in bytes, as an approximate indication of download time.

NASAFacts—The Earth Science Enterprise Series

http://eospso.gsfc.nasa.gov/eos_ homepage/misc_html/nasa_facts.html

The Earth Science Enterprise Series and the Earth Observing System Terra Series of NASA Fact Sheets are produced in an effort to educate the general public on the major issues and natural phenomena that scientists will be studying using data provided by the Earth Observing System.

Remote Sensing Data Visualization

http://rsd.gsfc.nasa.gov/rsd

You've seen some of these on the cover of *Time* and *National Geographic* magazines. These are just plain awesome visualizations!

Other Useful Web Sites

GOES (realtime GOES images)
http://rsd.gsfc.nasa.gov/goes

Earth From Space:
http://earth.jsc.nasa.gov
Best interface for astronaut photos of Earth from space.

Geomorphology From Space
http://daac.gsfc.nasa.gov/DAAC_DOCS/geomorphology/GEO_HOME_PAGE.html

Visible Earth
http://visibleearth.nasa.gov/Sensors

NASA Earth Science Enterprise
http://www.earth.nasa.gov

EarthKAM
http://www.earthkam.ucsd.edu

TOMS (ozone)
http://toms.gsfc.nasa.gov

SeaWIFS (ocean color)
http://seawifs.gsfc.nasa.gov/SEAWIFS.html

El Niño/La Niña
http://www.jpl.nasa.gov/elnino

NOAA Significant Event Imagery
http://www.osei.noaa.gov

Earth Today
http://www.nasm.si.edu/earthtoday

Face of the Earth
http://www.arcinc.com

EarthRISE
http://earthrise.sdsc.edu

Earth Alert
http://www.discovery.com/news/earthalert/earthalert.html

TeachEarth
http://teachearth.com
Resources for teaching and learning Earth system science.

Terraserver
http://www.terraserver.com
Amazingly high-resolution images of cities and famous places, somewhat marred by Terraserver watermarks. For sale.

Books with Earth Images

Orbit:NASA Astronauts Photograph the Earth, J. Apt, ISBN 0-792-23714-5

Seeing Earth from Space, Patricia Lauber, ISBN 0-531-05902-2

The Third Planet, Sally Ride, ISBN 0-517-59361-0

Satellite Atlas of the World, National Geographic, ISBN 0-7922-7216-1

America from Space, Thomas Allen, ISBN 1-55209-280-1

Satellite Atlas, David Flint, ISBN 0-8368-1677-3

Historical Landsat Data Comparisons, USGS,ISBN 0-607-01000-2

Out-of-Print Books Often Available through Web Book Services:

Embracing Earth, Payson Stevens, ISBN 0-811-80135-7

Looking at Earth, Priscilla Strain, ISBN 1-878-68516-3

Atlas of North America: Space Age Portrait of a Continent, Wilbur Garrett, ISBN 0-87044-605-3

The Home Planet, Kevin Kelley, ISBN 0-201-15197-9

Books about Changing Earth

Our Changing Earth, Thomas Canby, ISBN 0-87044-910-9

Geosystems: An Introduction to Physical Geography, Robert Christopherson, ISBN 0-13-505314-5

Posters

Spaceshots, Inc.
26943 Ruether Ave., Suite R
Santa Clara, CA 91351
1-800-272-2779
http://www.spaceshots.com

Map Appeal: Earth & Sky Portraits
1402 Pine Ave, Suite 827
Niagara Falls, NY 14301
1-800-363-0938
http://www.mapappeal.com

Raven Maps & Images
P.O. Box 850
Medford, OR 97501
1-800-237-0798
http://www.ravenmaps.com

Maps from US Geological Survey
Current and old maps and aerial photos available from local map stores or:
USGS
Box 25286, Federal Center
Bldg 810
Denver, CO 80225
1-800-435-7627

NASA Educational Resources

NASA has a multi-faceted education and public outreach program,including a comprehensive web site, printed educational materials, image sets, and other resources.

NASA Home Page:
http://www.nasa.gov

NASA Spacelink:
http://spacelink.nasa.gov

NASA CORE:
http://spacelink.nasa.gov/CORE

The guidebook, *How to Access Information on NASA's Education Program, Materials and Services* (EP-1998-03-345 HQ),is available through Spacelink.

For further information about NASA's Educator Resource Centers:
http://education.nasa.gov/ercn